Industry & Trade Summary

Abrasives

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This report was prepared principally by

Vincent DeSapio

Minerals, Metals, Machinery and Miscellaneous Manufactures Division
Industrial Minerals and Nonferrous Metals Branch

Address all communications to
Secretary to the Commission
United States International Trade Commission
Washington, DC 20436

PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on natural and manufactured abrasives covers the period 1989 through 1993 and represents one of approximately 250 to 300 individual reports to be produced in this series during the first half of the 1990s. Listed below are the individual summary reports published to date on the minerals, metals, and miscellaneous manufactures sector.

USITC publication number	*Publication date*	*Title*
2426	November 1991	Toys and models
2475	July 1992	Fluorspar and certain other mineral substances
2476	January 1992	Lamps and lighting fittings
2504	November 1992	Ceramic floor and wall tiles
2523	June 1992	Prefabricated buildings
2546	August 1992	Agricultural and Horticultural Machinery
2570	November 1992	Electric Household Appliances and Certain Heating Equipment
2587	January 1993	Heavy structural steel shapes
2623	April 1993	Copper
2633	June 1993	Textile Machinery and Parts
2653	June 1993	Glass containers
2692	November 1993	Refractory ceramic products
2694	November 1993	Flat glass and certain flat glass products
2706	April 1994	Aluminum
2738	February 1994	Structural ceramic products
2742	March 1994	Fiberglass products
2748	March 1994	Brooms, brushes, and hair-grooming articles
2756	March 1994	Air-Conditioning Equipment and Parts
2757	March 1994	Builders hardware
2758	March 1994	Semifinished steel
2765	April 1994	Metalworking Machine Tools and Accessories
2857	May 1995	Industrial Food-Processing Machinery and Related Equipment
2872	May 1995	Abrasives

[1] The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

CONTENTS

CONTENTS—*Continued*

INTRODUCTION

Abrasives and abrasive products are used to shape metal, wood, plastic, ceramic, or glass materials by cutting, grinding, boring, honing, lapping, polishing, buffing, sanding, blasting, and tumbling actions. Abrasives may be used in a variety of forms, including use as powders, loose grains, grains for bonding into grinding wheels, stones, grit and shot, or as coatings on cloth or paper. Their superior hardness, wear resistance, speed of operation, and refractory properties give abrasives advantages in a number of industrial applications involving the cutting and forming of metal components.

This summary covers abrasives and abrasive materials, which are included as parts of chapters 25, 28, 68, 71 and 72 of the *Harmonized Tariff Schedules of the United States (HTS)*, for the years 1989-93. Products contained in this summary include both natural abrasives (pumice, garnet, emery, tripoli, staurolite, and natural and synthetic industrial diamond[1]) and manufactured abrasives such as silicon carbide, fused aluminum oxide, cubic boron nitride, grinding wheels, coated abrasives, and grit and shot.

The unique properties of hardness, toughness, and fracture resistance of each type of abrasive product determine which abrasives to use to meet the combination of characteristics required for a specific application. In recent years, manufactured abrasives and synthetic diamond have been used increasingly in applications formerly reserved for traditional natural abrasives. This trend has occurred because of the development of superior quality, longer lasting manufactured abrasives and polycrystalline diamond which have become increasingly competitive in price with natural abrasives. Improvements in the quality of these synthetic products have also allowed manufacturers to take advantage of the wide availability of many of the common raw materials, such as aluminum, silicon, and carbon, which are used to manufacture these products. At the same time, manufactured abrasives and synthetic industrial diamond have served in a number of advanced applications where natural abrasives cannot be used because of mechanical and thermal limitations. The superior mechanical and thermal properties of today's advanced abrasives and superabrasives make them the products of choice for machining many of the superhard, advanced materials now used in the aerospace and automotive industries.

Despite shifts in market demand for various abrasive products within consuming markets during 1989-93, consumption of total abrasives increased by an estimated 17 percent during this period while U.S. production advanced by an estimated 18 percent (appendix A). Industrial diamond accounted for the largest share of trade in total abrasive products covered by this summary: 33 percent of total exports and 14 percent of imports. Demand for industrial diamond and other abrasives depends principally on the use of these materials by the automotive, machine tool, defense/aerospace, construction, and foundry industries.

Although abrasive products are manufactured in a number of nations, the United States remains the principal world supplier of these products. The United States dominates because of the following factors: (1) many of these materials, such as silicon carbide, cubic boron nitride, and synthetic industrial diamond were discovered and developed in the United States; (2) strong producer-customer supply relationships have allowed U.S. manufacturers to better anticipate customer needs; and (3) U.S. scientific and technological leadership has allowed U.S. manufacturers to develop many of the newer, advanced abrasives materials for the high-technology applications of today.

U.S. INDUSTRY PROFILE

Product Description and Attributes

Natural Abrasives

Natural abrasives[2] include such minerals as pumice, garnet, emery, tripoli, staurolite and industrial diamond (both natural and synthetic). Natural abrasives are widely used in such varied applications as impact finishing[3] and blasting; grinding wheels and cutting tools; tooling for the lapping[4] and polishing of lenses, semiconductor materials, ceramics, and metals; water filtration systems; nonslip surfaces such as flooring, boat decks, and airport runways; and consumer and industrial products such as toothpaste and tooth-polishing compounds, sandpaper, industrial

[1] According to the U.S. Bureau of Mines, synthetic industrial diamond is classified as a natural abrasive product because it is an exact substitute for natural diamond, a natural abrasive product. However, in many ways synthetic diamond demonstrates market characteristics similar to those of manufactured abrasives. Manufactured abrasives and synthetic diamond are increasingly used as substitutes for traditional natural abrasives and are also finding uses in a number of advanced applications.

[2] Establishments primarily engaged in the mining and manufacture of these products are classified as Miscellaneous Nonmetallic Minerals, Except Fuels (SIC 1499) and Abrasive Products (SIC 3291).

[3] Finishing of a surface through the rapid and repeated application of force.

[4] Finishing the surface of an object by having very fine abrasive particles rolled into its surface.

soaps, and metal- and jewelry-polishing compounds. In general, natural abrasive materials have lower hardness, lower strength, and less wear resistance than manufactured abrasives. As a result, manufactured abrasives are being used in many machining applications that natural abrasives once dominated. However, their generally low prices mean that natural abrasives are still widely used for applications requiring light load pressures, such as blasting, buffing, and polishing (table 1). Blasting applications are the largest single end-use market for most natural abrasives, accounting for nearly 50 percent of all consumption, and include such basic industrial processes as cleaning, deburring[5], etching, finishing, and peening[6]. Principal industries making use of natural abrasives for blasting purposes include building construction and maintenance, shipbuilding and ship maintenance, automobile, aerospace/defense, and structural steel fabrication. Principal natural abrasives included in this summary are described in table 2.

Manufactured Abrasives

Manufactured[7] (often called "man-made" or "synthetic") abrasives include such fused aluminum oxide, silicon carbide, cubic boron nitride, and metallic abrasives (metallic shot and grit). (To be consistent with industry practice, "synthetic" diamond, which shares many product and market characteristics with manufactured abrasives, are classified as natural abrasives in this summary.) These abrasives are typically produced in a granular or powder form, from where they may be either bonded or coated to tooling surfaces, or used in bulk form. The largest applications for manufactured abrasives include use in grinding wheels, which are used in milling, grinding, and polishing applications; tooling for use in boring, honing, broaching, sanding, and drilling applications; and use in refractory, blasting, polishing, and nonslip applications. Principal industries making use of abrasives include the automotive, machine tool, defense/aerospace, and steel and nonferrous fabrication industries (table 3). Principal manufactured abrasives included in this summary are described in table 4.

[5] The removal of sharp edges, or "burrs", from metal parts through use of abrasive machining.

[6] The mechanical working of metal by hammering or shot impingement.

[7] Establishments primarily engaged in the manufacture of these products are classified as Abrasive Products (SIC 3291).

Industry Structure

The U.S. abrasives industry is composed of nearly 47 firms operating 54 plants in both the United States and Canada.[8] Many of these firms are majority-owned by foreign multinational firms. Two primary features characterizing the U.S. abrasives industry in recent years have been industry consolidation to reduce overcapacity, and the substitution of manufactured abrasives and synthetic diamond for natural abrasives in many applications. Industry consolidation has resulted in a reduction in the number of firms in this industry, particularly among manufacturers of traditional natural abrasives such as emery and tripoli. The reduction in capacity has been prompted by declining demand in some markets as a result of (1) efforts of end-users in the machine tool, automobile, aerospace, and metal fabrication industries to reduce finishing requirements; (2) the substitution of plastics for metals in a number of durable goods; and (3) a continuing decline in expenditures by the U.S. defense industry, which uses large amounts of abrasives for the blasting of naval vessels and aircraft. Plant and capacity reductions have been most severe among manufacturers of traditional natural abrasives because manufactured abrasives and synthetic diamond have been absorbing a larger share of the abrasives market from traditional natural abrasives.

As the U.S. abrasives industry has reduced capacity, industry employment has also declined. Employment and wage data for the entire abrasives manufacturing industry are shown in table 5.

A factor affecting important segments of the U.S. industry for two decades has been the implementation of a number of environmental laws and regulations. The U.S. abrasives industry has been affected, both positively and negatively, by U.S. environmental regulations, especially regulations issued by the Environmental Protection Agency under the Clean Air Act (1972) and Clean Air Act Amendments of 1990.[9] These regulations have particularly affected, in a negative manner, producers of silicon carbide and, to a lesser extent, synthetic industrial diamond. Producers of silicon carbide have had difficulty meeting regulations governing sulfur dioxide emissions from electric resistance furnaces. A number of firms, reportedly exited the industry during the 1970s and 1980s because they did not find it economically feasible to attempt to meet emission requirements. No

[8] The majority of Canadian firms producing abrasives are U.S.-owned and this production is primarily used to satisfy abrasives demand in the United States and some demand by U.S. automakers and machine shops operating in Canada.

[9] 42 U.S.C. 7401, et. seq., as amended by P.L. 101-549, November 15, 1990; and P.L. 102-187, December 4, 1991.

Table 1
U.S. natural abrasives industry: Products, major product forms, end-uses, and physical properties

Products	Product forms	End-uses	Properties
Pumice	Grains and powder	Textile washing and cleaning	Hardness
Garnet	Grains and powder	Blasting, cleaning, grinding of metal surfaces, filtration systems	High hardness, inertness
Emery	Aggregate	Nonskid surfaces, deburring of metal, abrasive coatings	High hardness
Tripoli	Grains and fine powder	Paint filler and extender, buffing polishing compounds, toothpaste, industrial soaps	Fine grained, porous
Staurolite	Grains	Impact finishing of metals, blasting	Thermal conductivity, high melting point, high hardness
Industrial diamonds	Grit and powder	Grinding wheels, saws, lapping and polishing compounds	Extreme high hardness, durability, sharpness of edges
	Industrial stones	Drilling bits and reaming shells, saws, grinding wheels, dies; tools for dressing, cutting, boring, and finishing	
	Crushing bort	Grinding wheels, saws, lapping and polishing compounds	

Source: Industry contacts, technical articles, and company product literature.

Table 2
Natural abrasives: Product descriptions

Type	Description
Pumice	Pumice is essentially an aluminum silicate of igneous, or molten origin with a cellular structure formed by a process of explosive volcanism. Pumice (and pumicite) are formed when acidic magma is volcanically exploded into the air along a horizontal path before being deposited. In appearance, pumice is a light-colored, highly vesicular volcanic glass. The most important market for pumice is building block, accounting for 59 percent of all pumice consumed in the United States. Other important uses are in horticulture and landscaping, concrete aggregate, stone washing laundries, and abrasives.
Garnet	Garnet generally refers to a family of complex silicate minerals having similar physical properties and a crystalline form. The mineral occurs in many metamorphic rocks, including gneiss, schist, and metamorphosed limestone, and is a common constituent of beach sands and inland alluvial deposits. Garnet can be used in a number of applications: lower quality garnet may be used for blasting by the aluminum aircraft and shipbuilding industries and on oil rigs; the cleaning and conditioning of aluminum and other soft metals; and in water filtration systems. Higher quality industrial garnet is used as an abrasive powder for the lapping and grinding of glass, semiconductor materials, metals and ceramics; in abrasive wheels for grinding and finishing; and to manufacture coated and bonded abrasives. For many of the applications for which garnet is used there are no cost-effective substitutes. Consumption of garnet in blasting applications has grown considerably in recent years due to the enactment of environmental legislation that threatens the use of other abrasive products, principally those containing silica.
Emery	Emery is a gray-black rock containing various minerals, including corundum, magnetite, and hematite. Due to their superior hardness and strength, manufactured abrasives have replaced emery in many applications; however, emery is still used as an abrasive aggregate for nonskid, wear-resistant floors, pavements, and stair treads and in the manufacture of coated abrasives.
Tripoli	Tripoli includes material that is generally microcrystalline in nature, soft, friable[1], and porous with a silica content between 98 and 99 percent and with minor amounts of alumina, titania, and iron oxide. Because individual grains of tripoli lack distinct edges and corners they are not highly abrasive. As a result, tripoli is used in consumer and light industrial markets, such as toothpaste, industrial soaps, and buffing and polishing compounds, that require only mild abrasives.
Staurolite	Staurolite is a naturally occurring, complex, hydrated aluminosilicate of iron. This mineral most commonly occurs as opaque, reddish-brown to black crystals. As with garnet, staurolite is finding increased favor following environmental restrictions on the use of free silica abrasives, particularly in blasting.
Industrial diamond (natural and synthetic)	Natural and synthetic diamond that does not meet the standards for gem diamonds because their color, size, shape or structural defects are used as abrasives. Major categories of these diamonds include grit and powder; industrial stones (die stones, tool stones, and drilling stones); and crushing bort (small, irregularly shaped stones crushed into finer material). Grit and powder account for more than 90 percent of industrial diamond consumption. Natural diamond mining methods range from crude hand mining and panning to large-scale surface mining operations that use modern equipment to remove surface material and to mine and transport the diamond ore. Synthetic diamond is nearly identical to natural diamond in its fundamental properties but differs in purity, size, and shape. Synthetic is often superior to natural diamond because it has a single crystal structure and a roughly octahedral shape that provides multiple cutting edges. The primary method used to manufacture synthetic industrial diamond applies ultra-high pressures, through use of a hydraulic press, of up to 1.8 million pounds per square inch and temperatures as high as 2,400° C. to carbon-metal catalyst mixtures. Diamond abrasive and diamond cutting wheels are often

See footnote at end of table.

Table 2—Continued
Natural abrasives: Product descriptions

Type	Description
Industrial diamond (natural and synthetic)—**Continued**	bonded with resin, ceramic, or metal to create a bonded diamond abrasive. Principal industries using industrial diamond products include the mining and oil and gas exploration industries, which use diamond in core and rock drilling equipment, and the construction industry, which uses diamond abrasives in drilling bits and shells for foundation testing for dams and buildings and in masonry drilling, where diamond-impregnated grinding wheels and saws are used for cutting concrete, stone, ceramics, and composite materials. Industrial diamond grinding wheels are also widely used in the dressing and shaping of carbide machine tool tips, the grinding of dies, the edging of plate glass, and in optical grinding. A class of synthetic diamond that has emerged in recent years to assume a greater share of the industrial diamond market is polycrystalline diamond (PCD). Considered a superabrasive product, PCD contains tiny, randomly oriented diamond crystals joined to produce a cutting tool with highly uniform toughness and longer durability than conventional single crystal diamond tools.

[1] Ability of a material to crumble or break easily in order to expose new cutting surfaces.

Source: Industry contacts, technical articles, and company product literature.

Table 3
U.S. manufactured abrasives industry: Products, major product forms, end-uses, and physical properties

Products	Product forms	End-uses	Properties
Fused aluminum oxide	Grain	Bonded and coated abrasives, blasting, antislip, polishing compounds	High hardness, friability, chemical inertness
Silicon carbide	Grain	Bonded and coated abrasives, blasting, metal and quartz finishing, polishing and buffing compounds	High hardness, brittleness
	Whiskers and fibers	Metal-matrix and ceramic-matrix composites	High strength and elasticity
Cubic boron nitride	Grain	Lapping and polishing, drilling of hard ceramics, grinding wheels	Extremely high hardness, durability, chemical inertness, ability to operate at high speeds
Metallic abrasives	Grit and shot	Cleaning, deburring, and etching of metal products and parts	High hardness, recyclability

Source: Industry contacts, technical articles, and company product literature.

Table 4
Manufactured abrasives: Product descriptions

Type	Description
Fused aluminum oxide	Fused aluminum oxide (FAO), also called artificial corundum, is made by fusing calcined abrasive-grade bauxite with ground coke and iron filings in an electric arc furnace and allowing the material charge to cool slowly under controlled conditions. Currently, almost 85 percent of fused aluminum oxide production is regular brown grade (95 percent Al_2O_3) while the remaining material produced is high-purity (99.5 percent Al_2O_3). Regular-brown FAO is used in the manufacture of bonded, coated, blasting, anti-slip, and polishing abrasives. High-purity fused aluminum oxide cuts faster and cooler than regular brown, making it useful in the finishing of heat-sensitive metals and for use as a lapping and polishing compound in optical and gemstone applications.
Silicon carbide	Silicon carbide, one of the oldest known forms of manufactured abrasives, is produced by fusing silica sand (60 percent) and coke (40 percent) in an electric resistance (Acheson) furnace. An electric current is passed through the electrodes and the graphite core and the intervening silica sand-coke mix. When the temperature reaches about 2,400° C., the silica sand and carbon react to form abrasive grade silicon carbide pigs that are first crushed and then sized to meet a variety of industrial requirements. Most silicon carbide produced is known as black silicon carbide (containing 99 percent SiC) while the purest form, green silicon carbide, has a typical SiC content of over 99.5 percent. Silicon carbide is harder than aluminum oxide but also fractures more readily. In recent years, high-purity silicon carbide has been used in the form of fibers and whiskers as a reinforcing and strengthening agent in metal-and ceramic-matrix composite materials for advanced technology applications.
Cubic boron nitride	Cubic boron nitride (CBN) is produced using the same process as synthetic diamond, involving application of relatively high pressures and high temperatures of 2,000° C. and above. CBN is known as a "superabrasive" and delivers superior performance on such hard-to-grind material as aerospace metals. CBN approximates diamond in hardness and abrasion resistance and ranks high in chemical inertness. As a result, CBN grinding wheels last significantly longer than conventional abrasive wheels and can be run at higher temperatures and speeds.
Metallic abrasives	Metallic abrasives include steel shot and grit, chilled or annealed iron shot and grit, and cut wire shot. Steel and iron shot are produced by spraying molten metal through nozzles and cast into spheres by application of high pressure water sprays or by mechanical means. A hot water bath then cools the material. Cut wire shot is made by cutting wire of various diameters and materials. Steel shot and grit account for approximately 90 percent of metallic abrasives produced in the United States.

Source: Industry contacts, technical articles, and company product literature.

Table 5
U.S. employment and earnings data for abrasives manufacturing, 1989-93

Year	Total employment	Production workers	Average weekly earnings	Average hourly earnings
1989	22,700	16,100	$440.21	$10.19
1990	21,400	15,100	$435.76	$10.40
1991	20,400	14,900	$415.95	$10.22
1992	19,800	14,600	$420.25	$10.35
1993	19,400	14,400	$456.68	$10.67

Note.—Data is for SIC category 3291, which includes establishments primarily engaged in the manufacture of abrasives. Employment and earnings data for establishments primarily engaged in the mining of abrasives are not separately reported, but are included as part of data reported for SIC 1499.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

new silicon carbide plants have been built in North America since the 1970s. However, a number of manufacturers, including Exolon-Esk Co., have sought to comply with these regulations, using new technology that collects the offending gases and reduces sulfur dioxide emissions to levels that satisfy the regulations. Exolon-Esk is currently implementing technology that is projected to result in the complete elimination of sulfur dioxide furnace emissions.[10] The Clean Air Act and its amendments also affect producers of synthetic diamond. Large amounts of dust result from the use of fine nickel metal powder in the manufacture of diamond. However, the diamond industry does not consider regulations issued under the Clean Air Act and its amendments to be a major regulatory burden.

On the other hand, the Clean Water Act of 1972[11] (1977, 1981, and 1987 amendments) has opened a number of market opportunities for the garnet industry. Regulations issued under the Clean Water Act have served to increase the use of heavy-medium materials such as garnet in filtration systems while the substitution of garnet for silica sand avoids the health risk of silicosis associated with sand. The use of garnet also avoids the possibility of heavy metal contamination of ground water associated with the use of metal slags and it minimizes disposal problems because it can be recycled more often than many competing products can be.[12]

Natural Abrasives

Except for the markets for synthetic industrial diamond and garnet, the U.S. industry for natural abrasives mining and manufacturing has experienced contracting markets for its products in recent years. This happened largely because of lower demand by traditional end-users, the declining quality of domestic reserves, and the emergence of manufactured abrasives as effective substitutes as manufactured abrasives producers have been able to reduce the prices of their products relative to natural abrasives while producing materials that last from two to three times longer than natural abrasives. As a result, the number of U.S. firms mining or manufacturing natural abrasives has declined, from 29 in 1989 to approximately 24 in 1993 (table 6).

Two emery-mining operations closed during the late 1980s because of diminishing markets, declining quality of reserves, and tightening of environmental regulations covering drilling and blasting.[13] The single remaining U.S. producer owns four emery deposits in Oregon from which it produces material of generally high purity, hardness, and toughness. Two major U.S. firms producing tripoli exited the industry during the early 1990s, at a time the industry had experienced production declines for a number of years because of declining use in its key abrasives markets. Staurolite is mined as a byproduct of DuPont's heavy mineral sands operation in Florida and has enjoyed a modest resurgence in demand during the 1990s, following the introduction of more restrictive environmental laws regulating the use of silica in abrasives applications.[14]

Health hazards associated with competing materials, such as silica sand, have improved prospects for U.S. garnet miners, resulting in plans for mine expansions. World garnet production has doubled within the last 10 years and the United States has been the dominant world producer, accounting for nearly 45 percent of estimated world production of almost 130,000 short tons.[15] U.S. garnet producers are presently operating close to full capacity of nearly 60,000 short tons with production in 1993 more than 25 percent above levels reached in 1989. Because of promising markets for garnet, Western Garnet Co.[16] announced plans in 1993 to expand its capacity in order to raise its production in Idaho to 66,000 short tons per annum, with particular emphasis on supplying water jet cutting markets and other markets.[17] At the same time, NYCO Minerals has announced plans to develop additional wollastonite ore reserves in New York, from which the firm produces garnet as a byproduct.[18]

There were three U.S. producers of synthetic industrial diamond in 1993 and an additional two firms who manufacture polycrystalline diamond from purchased synthetic diamond grit. Production of synthetic diamond has grown over the past 5 years as reductions in the cost of these materials and improvements in material properties have expanded its product applications. At present, synthetic diamond accounts for nearly 80 percent of industrial diamond used, as declining prices and the ability to improve the quality of synthetic diamond have resulted in increases in many of the mineral, oil and gas, and construction

[10] Michael O'Belinsky, Exolon-Esk Co., telephone interview by USITC staff, Washington, DC, Nov. 1994.
[11] 33 U.S.C. 1251, et. seq.
[12] James Hansink, Emerald Creek Garnet Co., telephone conversation, with USITC staff, Washington, DC, Dec. 1994.
[13] Bruce McMichael, "Abrasive Minerals: Taking the Rough With the Smooth," *Industrial Minerals*, Feb. 1990, p. 31.
[14] U.S. Bureau of Mines, "Abrasive Materials," *1992 Annual Report*, prepared by Gordon T. Austin, p. 1.
[15] Ibid., p. 9.
[16] Western Garnet has been a Canadian-owned company since being acquired in 1991.
[17] Mike O'Driscoll, "Garnet: Set for Blast Off?" *Industrial Minerals*, Jan. 1993, p. 21.
[18] Ibid., p. 22.

Table 6
Natural abrasives: U.S. producers, location of production facilities, 1993

Product	Production facility	Location
Pumice	Tufflite Inc.	Arizona
	California Industrial Minerals	California
	Glass Mountain Pumice Inc.	California
	U.S. Pumice Co.	California
	Hess Pumice Products	Idaho
	Producers Pumice Inc.	Idaho
	Calvert Corp.	Kansas
	Kansas Minerals Inc.	Kansas
	Copar Pumice Co.	New Mexico
	General Pumice Corp.	New Mexico
	Cascade Pumice Co.	Oregon
	Central Oregon Pumice Co.	Oregon
Garnet	Barton Mines Corp.	New York
	NYCO Minerals Inc.	New York
	Western Garnet Co.	Idaho
Emery	Oregon Emery Inc.	Oregon
Tripoli	Malvern Minerals Co.	Arkansas
	American Tripoli Co.	Oklahoma
	Unimin Specialty Minerals Inc.	Illinois
	Keystone Filler & Mfg. Co.	Pennsylvania
Staurolite	DuPont & Co.	Florida
Synthetic diamond[1]	General Electric Co.	Ohio
	DuPont Industrial Diamond Div.	New Jersey
	Suprahards Inc.	New Jersey

[1] There are no U.S. reserves or production of natural industrial diamond.
Source: Compiled from industry contacts, technical articles, and product literature.

applications formerly reserved for natural diamond. Although industrial diamonds are expensive, they are often more cost-effective than other abrasives over the long-term because of their durability. General Electric Co. (GE) has been the world's largest manufacturer of synthetic industrial diamond since it introduced these materials in 1955. In addition to its production facility in Ohio, GE also has a synthetic diamond production facility in Ireland. There has been no production of natural industrial diamond in the United States during 1989-93.

The wide variety of natural abrasives available and the wide variety of end-use markets served make it difficult to generalize about the distribution methods used to bring these products to market. However, it appears that most natural abrasives are shipped directly from the mining and processing site, generally in a granular form, to end-users, by truck or rail. Transportation costs are often a key factor in the final cost of natural abrasives, often accounting for nearly 50 percent of final product cost. Of course, inland or remote mineral deposits are likely to be more expensive than alluvial[19] or beach sand deposits on the coast or near the marketplace.[20] Because of the homogeneous nature of these products and the stiff competition from less expensive imported products and substitute materials, such as manufactured abrasives, natural abrasive products tend to be highly price-sensitive, with significant discounting of prices during periods of excess capacity.

Manufactured Abrasives

During the last 5 years, the U.S. manufactured abrasives industry has shown only modest growth as many of the markets into which the U.S. industry sells its products—the aerospace, automotive and steel industries in particular—have been able to achieve significant reductions in finishing requirements. At the same time, declines in military spending have adversely affected the defense market for many of these products. The domestic manufactured abrasives industry has undergone major restructuring as a result of mergers, corporate downsizing, and plant closings. This restructuring has resulted in a decline in industry employment and in capacity reductions. Several large firms, including Carborundum Co. and Ferro Corp., have left the industry while others, including Norton

[19] Referring to material deposited by flowing water, as in a riverbed or delta.

[20] O'Driscoll, p. 26.

Co., the largest firm in the industry, were sold to foreign manufacturers.[21]

By year end 1993, there were four U.S. firms producing fused aluminum oxide at nine plants in the United States and Canada with joint annual U.S. and Canada industry capacity of the four firms of nearly 310,000 short tons.[22] In 1992, the U.S. industry operated at approximately 60 percent of capacity. Production and capacity utilization rates for this industry have dropped in recent years due to reduced demand by principal end-users. The automotive industry, the largest single user of these products, and the defense/aerospace industry, which uses fused aluminum oxide as a blasting medium for removal of corrosion on aircraft, both have reduced their use of this material in recent years. During the peak in U.S. defense spending in the mid-1980s, the defense/aerospace industry was one of the largest consumers of fused aluminum oxide.

During 1993, 8 U.S. firms produced refined silicon carbide at 10 plants in the United States and Canada.[23] Norton Co., Exolon-Esk Corp. and American Treibacher were the only U.S. producers of crude silicon carbide grain during 1993, with annual North American capacity estimated at 110,000 short tons and production totaling an estimated 80,000 short tons.[24] During the late 1980s, the combination of declines in the consumption of silicon carbide by the automotive and steel industries, the increased imports of less expensive imported silicon carbide grain, and the imposition of tougher U.S. and state air-quality standards regarding the emission of sulfur dioxide gas from electric furnaces, reportedly forced a number of firms, including Carborundum Co. and Ferro Corp., either to close plants or to exit the industry.[25] In addition to plant closings, the North American silicon carbide industry also witnessed a steady consolidation of operations as manufacturers sought to eliminate excess capacity by closing divisions and combining operations through mergers.

Manufactured abrasives are typically sold by manufacturers either directly or through distributors. Larger abrasives markets tend to be served by distributors while smaller markets tend to be served by sales forces employed by the manufacturer. Distributors generally are either owned by the manufacturer or independently operated and often perform some processing of the abrasive product.[26] The decline in demand for abrasive products by important end-use industries has forced major adjustments in the purchasing and inventory practices of manufacturers, distributors, and end-users of abrasives. In an effort to reduce their total abrasives costs, end-users are now ordering abrasives on an "as-needed" basis from distributors, by timing their abrasives purchases to correspond more closely to their production schedules.[27] As such, end-users have adopted "just-in-time" purchasing methods that ensure a consistent level of abrasives in their inventories. This trend has forced manufacturers and distributors of abrasives to become more "customer driven" by maintaining closer contacts with end-users in an effort to better anticipate customer needs and to respond more quickly to changing market conditions. The emphasis on servicing customer needs has also meant that abrasives manufacturers and distributors have increasingly focused on providing technical assistance to allow end-users to derive the maximum efficiencies possible by using these products in the designed manner.[28]

Foreign entry into the U.S. market has recently become significant. It consists largely of the purchase of domestic firms by foreign firms. Among leading manufacturers in the industry, Norton Inc. is now wholly owned by Saint-Gobain, a French multinational firm; Exolon-Esk is 50 percent owned by ESK in Germany; and American Treibacher is Austrian-owned. Producers of manufactured abrasives and their plant locations in the North America are listed in table 7.

Consumer Characteristics and Factors Affecting Demand

Three primary factors affecting demand for abrasives in end-use markets are product quality, cost, and level of demand for end-use products. Success for firms in this industry has depended on consistently providing a quality product to market specifications at a price competitive with substitute products. Users of abrasives evaluate the materials they buy based on a variety of properties, which include toxicity, inertness, angularity, grain size, hardness, and specific gravity. The particular combination of properties required will

[21] Norton Co. was sold to Saint-Gobain of France in 1992.

[22] Gordon Austin, U.S. Bureau of Mines, telephone interview by USITC staff, Washington, DC, Sept. 1994.

[23] Canadian abrasives producers are included in this discussion of the U.S. industry because the bulk of abrasives capacity in Canada is owned by firms based in the United States and the two markets are well-integrated as firms in Canada supply large quantities of material to end-users in the United States.

[24] Roger Loughborough, "Silicon Carbide: Market Grinds to Recovery," *Industrial Minerals*, Nov. 1994, p. 53.

[25] McMichael, p. 26.

[26] Ted Giese, Abrasive Engineering Society, telephone interview by USITC staff, Washington, DC, Nov. 1994.

[27] Richard B. Kennedy, "Abrasives Weather the Storm," *Purchasing World*, Dec. 1990, pp. 57-8.

[28] *Industrial Distribution-Cutting Tools & Abrasives Handbook Supplement*, Mar. 1993, p. 6.

Table 7
Manufactured abrasives: North American producers, location of production facilities, 1993

Product	Production facility	Location
Fused aluminum oxide	Washington Mills Electro Minerals Corp.	Canada
		New York
	Exolon-Esk Co.	Canada
	American Treibacher Corp.	New York
		Canada
	Norton/Saint-Gobain Inc.	Alabama
		Canada
	Washington Mills Ltd.	Canada
		New York
Silicon carbide	Exolon-Esk Co.	Illinois
		New York
	American Treibacher Corp.	New York
		Canada
	Norton/Saint-Gobain Inc.	Canada
	Carborundum	New Jersey
	Detroit Abrasives	Michigan
	Electro Abrasives	New York
	Minnesota Mining & Mfg. (3M) Inc.	Minnesota
	Washington Mills Ltd.	New York
Cubic boron nitride	General Electric Co.	Ohio
Metallic abrasives	Abrasive Materials Inc.	Michigan
	Barnsteel Abrasives	Pennsylvania
	Chesapeake Specialty Products	Maryland
	Durasteel Abrasive Co.	Pennsylvania
	Ervin Industries Inc.	Michigan
		Pennsylvania
	Metaltec Steel Abrasives Co.	Michigan
	National Metal Abrasive Co.	Ohio
	Pellets Inc.	New York
	The Wheelabrator Corp.	Virginia

Source: Compiled from industry contacts, technical articles, and product literature.

depend on the particular application for which the abrasive will be used. Sales of abrasives to the high-volume automotive industry, for instance, tend to be characterized by significant price-competition for the following reasons: the emergence of near-net-shape[29] processing (which has been used to reduce the use of abrasives), the substitution of components made from plastics and resins for metal parts, and the high degree of substitutability and homogeneity between various commodity-type abrasives. In addition, bulk sales of abrasives used in filtration systems and of blasting abrasives to the construction, shipping and aerospace industries are also highly price-sensitive. On the other hand, advanced abrasives and superabrasives are sold in much smaller markets where price considerations are less important than the particular qualities of the abrasive required. An example of such a market is the aerospace industry, where higher value advanced abrasives are used to machine difficult materials such as hard ferrous metals, cast iron, nickel and cobalt-based superalloys.

Natural Abrasives

Despite reduced defense/aerospace spending, which has adversely impacted the use of natural abrasives as a blasting medium on aircraft and in shipyards, the blasting market remains the primary consumer of these products.[30] Natural abrasives are still widely used in the blasting of the surfaces of buildings and major structural steelwork such as bridges. In many of these applications, the higher cost of certain manufactured abrasives and the toxic hazards of substitute products justify the use of natural abrasives. Garnet is the most widely used natural abrasive in blasting applications, having enjoyed

[29] Any of a number of forming methods that are used to produce a semi-manufactured part that is close to the final manufactured part. Such processing eliminates the need for extensive grinding or finishing operations.

[30] Gordon T. Austin, "Blasting Abrasives in the United States Market," paper read at the annual meeting of the Society for Mining, Metallurgy and Exploration, Inc., Feb. 1994.

renewed popularity due largely to the health hazards associated with competing products such as silica sand and metal slag. In addition to the blasting market, garnet also shows great potential for use in water jet cutting, where the material is delivered by high water pressure to cut such materials as steel, concrete, and composites in volatile environments near oil wells and gas pipes and in oil refineries. Market demand for garnet in the blasting market is expected to rise to 50,000-60,000 short tons per year, compared with current demand of nearly 25,000-30,000 short tons per year.[31] Water jet cutting demand for garnet is presently estimated at 5,000-8,000 short tons, with demand growing at 15 percent per annum.[32]

Manufactured Abrasives

Demand for U.S. manufactured abrasives has been greatly dependent on demand by heavy industrial users such as the machine tool, automotive, defense/aerospace, and steel and nonferrous metals fabrication industries, which are the principal consumers of these products. In recent years, demand for manufactured abrasives has matured and leveled off as the automotive industry, in seeking to reduce vehicle weight to meet government-mandated fuel economy standards, has sought to substitute molded plastic for metal components. The weight of an average car has fallen nearly 540 pounds during the last 20 years as average steel use in each automobile has declined from 2,223 pounds in 1976 to 1,727 pounds in 1993. Smaller volumes of material to be finished translates into reduced orders for machine tools and reduced need for abrasives. During the same period, the use of plastics and plastics composites increased from an average of 155 pounds to nearly 245 pounds per automobile.[33] Plastics generally do not require finishing by abrasives. In addition, a number of metal-processing industries, such as the steel foundry industry, have increased efficiency over the last decade by making castings to near-net final shapes with closer tolerances, thereby reducing the amount of stock removal required in final finishing operations. Cutbacks in defense spending have also adversely affected machine tool orders and abrasives demand by the defense/aerospace industry.

Although traditional markets for manufactured abrasives appear to have peaked in recent years, the market for advanced abrasives, used in specialized applications, including the machining of advanced ceramics and metal- or ceramic-matrix composites, has begun to show great promise.[34] Sol-gel (SG) abrasives are an example of one type of advanced abrasive. Norton/Saint-Gobain and Minnesota Mining and Manufacturing (3M) are currently the only U.S. manufacturers of SG abrasives. Norton uses its proprietary Seeded Sol-Gel technology to manufacture advanced aluminum oxide abrasives for use in the aerospace industry and in applications where extremely hard abrasives for the grinding or dressing of difficult materials are required. Advanced SG abrasives are often superior to fused aluminum oxides because they avoid the fracturing and resultant metal damage that may occur through use of fused aluminum oxides. In addition to aerospace applications, actual and potential applications for advanced abrasives using SG may include grinding, dressing, and deburring applications in the automotive, foundry, and metal and metal-matrix composite fabrication industries. Although the volume of advanced abrasives materials sold is presently small, price margins for these products are generally high because of the higher value-added nature of these products.

FOREIGN INDUSTRY PROFILE

Global sales of all abrasives are estimated to have reached $6 billion in 1993;[35] U.S. producers accounted for approximately 35-40 percent of global production. The status of producers in the world abrasives markets varies by product. Production of natural abrasives depends greatly on the existence of proven quality deposits of these minerals, the mining conditions of the deposit, location of the deposit relative to markets and infrastructure, milling costs, and commercial potential of the material.[36] Because raw materials used in the production of manufactured abrasives tend to be fungible and to be traded widely in international markets, competitiveness in these products tends to depend on such factors as manufacturing process efficiencies, the technical ability of producers to manufacture newer, more advanced materials to meet customer needs, and the ability to service customer needs by solving technical and product applicability problems.[37] The worldwide market for manufactured abrasives tends to be dominated by the United States and advanced industrial nations in Europe and Asia. The market for natural abrasives tends to be dominated by producers in the United States and such nations as South Africa, Australia, India, Turkey, and Zaire, which have high-quality, accessible deposits of these minerals. However, infrastructure limitations and the threat of civil unrest in several of these countries, such as Zaire, affect the ability to bring these minerals to market.

[31] O'Driscoll, p. 29.
[32] Ibid., p. 30.
[33] *AAMA Motor Vehicle Facts & Figures*, 1993, p. 50.
[34] Giese, Aug. 1994.
[35] *Industrial Distribution-Cutting Tools & Abrasives*, Mar. 1993, p. 5.
[36] U.S. Bureau of Mines, p. 5.
[37] "Abrasives Markets are Alive and Well," *Industrial Distribution*, Apr. 1994, p. 34.

Natural Abrasives

In contrast to the generally expanding worldwide markets for natural abrasives in the form of synthetic diamond and garnet, the markets for natural abrasives in the form of natural industrial diamond, pumice, emery, and tripoli were characterized by excess levels of world inventories and weak demand caused by declining end-use markets and competition from manufactured abrasives. Worldwide annual production of natural industrial diamond remained at approximately 56 million carats during 1989-93, with little growth anticipated. By contrast, worldwide production of synthetic diamond and garnet experienced significant growth as major producers expanded capacity significantly; worldwide garnet production in 1993 nearly doubled from 1989 levels while synthetic diamond production worldwide increased by nearly 20 percent from 1989 levels.

With the exception of industrial diamond, producers of natural abrasives worldwide generally consist of small private or state-owned mining companies. World production and trade in industrial diamond is dominated by De Beers Consolidated Mines Ltd. (South Africa) and General Electric Inc., two large multinational firms with sophisticated international trading operations.

Pumice

Italy was the leading global producer and supplier of pumice and related materials, accounting for nearly 50 percent of world production of 11.8 million short tons. Other leading producers in 1993 included Greece, Turkey, and Spain with 8, 7, and 7 percent, of world production, respectively.

Garnet

The world garnet market is dominated by only a very few producers. Australia is the second-largest world producer and exporter of garnet with total annual production in 1992 of 20,000-25,000 short tons, compared with production of nearly 10,000 short tons in 1987. The only significant Australian producer, Garnet Millers Associates Pty. Ltd. (GMA) is 50 percent owned by Barton Mines of the United States.[38] GMA is presently producing at near full capacity with its garnet sold for blasting, water filtration, water jet cutting, and polishing and lapping applications. Total exports by GMA amounted to nearly 6,000 short tons in 1992 and all were sold to Barton Mines.[39]

Production of garnet in India is dominated by V.V. Minerals, which produces nearly 16,000 short tons annually, of which nearly 70 percent is exported to Southeast Asia (principally Japan), Europe, and the Middle East, principally for blasting and precision lapping applications. Elsewhere in India, Indian Rare Earths Ltd. produces 2,000-3,000 short tons of garnet annually.[40] China is said to have extensive reserves of garnet, but estimates of its annual production vary from as low as 2,000 short tons to as high as 20,000 short tons. In light of the present strong world demand for garnet, a number of world producers, including producers in Canada and Europe, have announced major expansion plans.[41]

Emery

World production of emery is limited to Turkey, Greece, and a lone U.S. producer. Three firms account for the bulk of Turkish production—Etibank, Ranar Minerals Industries Corp., and Lutfullah E. Kitapci Minerals Co. Total Turkish emery production in 1992 was estimated by the U.S. Bureau of Mines to be in excess of 22,000 short tons.[42] Etibank is Turkey's principal exporter of emery, selling primarily to markets in Europe and the United States.

Greek production, totalling nearly 11,000 short tons in 1992, is state controlled.[43] Deposits are mined on the island of Naxos by local villagers. Nearly 50 percent of the output is exported in lump form to be further processed, while the remaining material is further processed on the mainland. The emery produced by Greece is used in a variety of applications, including grinding wheels, millstones, coated abrasives, and nonskid surfaces.[44]

Tripoli

The United States is the only country in the world with significant production of tripoli.

Staurolite

The United States is the dominant world producer of staurolite. India produces small amounts of staurolite for local consumption.[45]

Industrial Diamond (Natural and Synthetic)

Australia and Zaire were the world's largest producers of natural industrial diamond, accounting for 38 percent and 22 percent, respectively, of total world production of 56 million carats in 1993. Each country was a primary supplier of both natural crushing bort and industrial stones. Argyle Diamond Mines Pty Ltd. is Australia's largest producer, accounting for nearly 90 percent of total Australian production in 1993. Nearly

[38] O'Driscoll, p. 22.
[39] Ibid.
[40] Ibid., p. 26.
[41] Ibid., p. 24.
[42] U.S. Bureau of Mines, p. 10.
[43] Ibid.
[44] Ibid.
[45] Ibid.

90 percent of Argyle's production of natural diamond is exported to major industrial markets in Asia, the United States, and Europe where they are cut and polished. Production in Zaire is dominated by Societe Miniere de Bakwanga (MIBA), a largely state-owned diamond mining company. Nearly 50 percent of MIBA production is industrial diamond.

The United States was the world's leading producer of synthetic industrial diamond in 1993, accounting for nearly 30 percent of world production. South Africa, Ireland, and Russia were the next largest producers, each with 20 percent of world production. Because DeBeers Consolidated Mines Ltd. and General Electric Inc. together account for nearly 70 percent of all synthetic industrial diamond produced worldwide, they reportedly are able to exert a large degree of control over the world price of diamond.[46] In addition to its production facility in the United States, GE also produces synthetic diamond in Ireland, from which it is a major exporter.

Manufactured Abrasives

Western Europe was second only to the United States and Canada in production of manufactured abrasives during 1989-93. Fused aluminum oxide and silicon carbide have long been produced in certain regions of North America and Western Europe where abundant sources of inexpensive hydroelectric power exist. Japanese production of manufactured abrasives is still largely dedicated for domestic consumption while Chinese production and exports are still small, although growing rapidly. In recent years, low-cost foreign competitors, such as China, have emerged to challenge U.S. dominance in the highly price-elastic and low-margin end of the abrasives market.[47] Foreign producers of manufactured abrasives have been affected by many of the same changes in the market place that have affected U.S. producers. The principal market for manufactured abrasives worldwide is the automobile market. The general trend toward lighter automobiles that substitute nonmetal for metal components to more easily satisfy fuel economy requirements has resulted in lower worldwide demand for abrasives. Western European manufacturers have responded to tighter markets for traditional manufactured abrasives by attempting to develop advanced abrasives for high-technology applications.

[46] Peter Harben and Richard Notstaller, "Diamonds - Scintillating Performance in Growth and Prices," *Industrial Minerals*, Mar. 1991, pp. 43-46.

[47] Peter Williams, Washington Mills Abrasives Inc., telephone interview by USITC staff, Washington, DC, Aug. 1994; and Jeff Wherry, Abrasive Grain Association, telephone interview by USITC staff, Washington, DC, Nov. 1994.

Fused Aluminum Oxide

China and the United States are reported to be the leading worldwide producers of fused aluminum oxide (FAO), accounting for a combined total of more than approximately 50 percent of world production. The two principal firms producing in China are Grinding Wheel No. 2 and Grinding Wheel No. 7, which primarily produce regular brown grade FAO. Total Chinese annual capacity to produce regular brown grade FAO is 400,000 short tons, of which nearly 50 percent is estimated to come from the two large Chinese plants.[48] Leading European producers include Treibacher (Austria), which has plants in the United States, H.C. Stark (Germany), and St. Gobain (France). Other leading worldwide producers include Australia Fused Minerals (jointly owned by Alcoa, Japan Abrasives, and Devex), Union Corp. and General Chemical Corp. in Korea, and Fuso (Brazil).

Silicon Carbide

Silicon carbide is produced at nearly 30 production facilities worldwide, with global production totaling nearly 600,000 short tons per year.[49] Due to cutbacks worldwide among end-users and the presence of less expensive imports in world markets, a number of major producers, including Samatec SpA (Italy) and Pechiney Electrometallurgie (France), have left the industry during the last 5 years.

Western Europe is a major producer of silicon carbide, accounting for approximately 180,000 short tons annually, or nearly 30 percent of world capacity.[50] Major production facilities are located in the Netherlands, Norway, and Spain. The largest producer in Europe, accounting for nearly 40 percent of capacity, is Elektroschmelzwerk Delfzijl BV (ESD) (Netherlands), which is a subsidiary of the German firm, Electroschmelzwerk Kempten GmbH (ESK). The second leading producer in Europe is the Norwegian producer, Arendal-Smeltwerk A/S (SIKA), which is now a subsidiary of Norton/Saint-Gobain Inc. In recent years, China has also become a significant producer and world supplier of lower-quality silicon carbide grain, with annual capacity estimated at 220,000 short tons. China has numerous small producers located throughout the country. The principal exporters of silicon carbide include Chinese Abrasive Export Co., Tianjin Leadar (Group), and Grinding Wheel No.7.

As is the case with producers in the United States, the issue of sulfur dioxide emissions from silicon carbide furnaces has become a major issue for Western European producers of silicon carbide. State

[48] Eugene Lunghofer, EPL Ind., telephone interview by USITC staff, Washington, DC, Oct. 1994.

[49] Loughborough, p. 51.

[50] Ibid.

environmental regulations have forced certain Western European producers to install costly state-of-the-art technology to reduce these emissions.[51]

U.S. TRADE MEASURES[52]

Natural Abrasives

U.S. rates of duty, as of January 1, 1994, applicable to imports of natural abrasives under the *HTS* are provided in table 8. The table shows the column-1 rates of duty for table 8 countries that have most-favored-nation (MFN) status, as well as rates of duty for countries qualifying for special tariff programs. The average ad valorem column-1 duty rate for these products in 1993 was 0.1 percent. Column-1 duty rates for 1993 ranged from duty-free to 4.9 percent. These duty rates are not considered to be a limiting factor in the entry of foreign natural abrasives into the U.S. market. Because tariff duties on abrasives entering the United States from member countries of General Agreement on Tariffs and Trade (GATT) are already low, the effect of duty reductions agreed to in the Uruguay Round of trade negotiations on current duties will be negligible. Most current U.S. imports are from member countries of the GATT.

There are currently no known U.S. nontariff measures that affect trade in natural abrasives. No statutory investigations involving imports of natural abrasives have been instituted during the past 5 years.

Manufactured Abrasives

U.S. rates of duty, as of January 1, 1994, applicable to imports of manufactured abrasives under the *HTS* are provided in table 9. The table shows the column-1 rates of duty for countries that have MFN status, as well as rates of duty for countries qualifying for special tariff programs. The average ad valorem column-1 duty rate for these products in 1993 was 1.3 percent. Column-1 duty rates for 1993 ranged from duty-free to 4.9 percent ad valorem. These duties are not considered a limiting factor in the entry of foreign manufactured abrasives in this market. Because tariff duties on abrasives entering the United States from member countries of GATT are already low, the effect of duty reductions agreed to in the Uruguay Round of trade negotiations on current duties will be negligible. Most current U.S. imports are from member countries of the GATT. There are currently no known U.S. nontariff measures that affect trade in manufactured abrasives.

The Commission has conducted only one investigation since 1989 with respect to imports of manufactured abrasives. In June 1994, in an investigation conducted under the U.S. antidumping law (19 U.S.C. 1673 et. seq.), the Commission determined that an industry in the United States was not materially injured or threatened with material injury by reason of imports from China of silicon carbide.[53]

FOREIGN TRADE MEASURES

Natural Abrasives

During 1989-93, the major foreign markets for U.S. producers of natural abrasives were Canada, the European Union (EU), and Japan. In 1994, foreign tariff rates for natural abrasives exported from the United States to the EU ranged from duty free to 3.2 percent ad valorem. With the exception of a 3-percent ad valorem rate on exports to Japan of miscellaneous emery, natural corundum, natural garnet and other natural abrasives, products from the United States entered Japan duty free in 1994. All remaining duties on U.S. goods covered by this summary entering Canada were phased out on January 1, 1994 under terms of the North American Free Trade Agreement (NAFTA). Exports of natural abrasives from the United States entering Mexico ranged from duty-free to 10 percent ad valorem in 1994. Under terms of NAFTA, all remaining duties on goods entering Mexico from the United States are due to be phased out by January 1, 1998. Because tariff duties on abrasives entering member countries of GATT from the United States are generally low, the effect of duty reductions agreed to in the Uruguay Round of trade negotiations on existing duties will likely be negligible. Most current U.S. exports are to member countries of the GATT. Foreign tariffs are not considered by U.S. manufacturers to be a significant factor in limiting U.S. exports of natural abrasives. The Commission is unaware of any nontariff barriers that affect U.S. exports of natural abrasives.

Manufactured Abrasives

During 1989-93, Canada, the EU, and Japan were the major foreign markets for U.S. producers of manufactured abrasives. In 1994, EU tariff rates ranged between 2 and 8 percent ad valorem on manufactured abrasives products imported from the United States. Japanese tariff rates ranged between 2.2 and 5.2 percent ad valorem on U.S. manufactured abrasives. Exports of manufactured abrasives from the United States entering Canada ranged in duty from free to 6.5 percent ad valorem in 1994. Under terms of the NAFTA, all remaining duties on goods entering

[51] McMichael, p. 27.

[52] See appendix B for an explanation of tariff and trade agreement terms.

[53] USITC, *Silicon Carbide From the People's Republic of China*, investigation No. 731-TA-651 (Final), USITC publication 2779, June 1994.

Table 8
Natural abrasives products: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994; U.S. exports, 1993; and U.S. imports, 1993

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1994 General	Special[1]	U.S. exports, 1993	U.S. imports, 1993
				1,000 dollars	
2513.11.00	Pumice, crude or in irregular pieces, including crushed pumice	Free		1,758	4,201
2513.19.00	Pumice, other than crude, crushed or in irregular pieces	0.3¢/kg.	Free (A,CA,E,IL,J,MX)	6,111	635
2513.21.00	Emery, natural corundum, natural garnet and other natural abrasives, crude or in irregular pieces	Free		1,161	1,450
2513.29.00	Emery, natural corundum, natural garnet and other natural abrasives, other	0.7¢/kg.	Free (A,CA,B,IL,J,MX)	12,852	1,461
7102.21.10	Unworked miner's diamonds	Free		1,993	0
7102.21.30	Industrial diamonds simply sawn, cleared or bruted	4.9%	Free (A,CA,E,IL,J,MX)	50	1,859
7102.21.40	Industrial diamonds, unworked, other	Free		2,939	16,417
7102.29.00	Other industrial diamonds	Free		1,896	0
7105.10.00	Diamond powder and dust, 80 mesh or finer	Free		136,158	69,766
7105.90.00	Dust and powder of natural or synthetic stones, other	0.7c/kg.	Free (A,CA,E,IL,J,MX)	3,156	285

[1] Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A); Automotive Products Trade Act (B); North American Free-Trade Agreement, Goods of Canada (CA) and Mexico (MX); Caribbean Basin Economic Recovery Act (E); United States-Israel Free Trade Area (IL); and Andean Trade Preference Act (J).

Source: U.S. exports and imports compiled from official statistics of the U.S. Department of Commerce.

Table 9
Manufactured abrasives products: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994; U.S. exports, 1993; and U.S. imports, 1993

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1994 General	Special[1]	U.S. exports, 1993	U.S. imports, 1993
				1,000 dollars	
2818.10.10	Crude artificial corundum	Free		17,878	49,342
2818.10.20	Artificial corundum, grain, or ground, pulverized or refined	0.7¢/kg	Free (A,CA,E,IL,J,MX)	10,056	27,546
2849.20.10	Carbide of silicon, crude	Free		1,508	44,574
2849.20.20	Carbide of silicon, in grains, or ground, pulverized or refined	0.7¢/kg	Free (A,CA,E,IL,J,MX)	14,267	13,350
2849.90.10	Carbides, of boron	3.7%	Free (A,CA,E,IL,J,MX)	306	4,607
6804.10.00	Millstones and grindstones for milling, grinding or pulping	Free	Free (A,CA,E,IL,J,MX)	2,840	2,870
6804.21.00	Other millstones of agglomerated synthetic or natural diamond	4.9%	Free (A,E,IL,J,MX) 1.9% (CA)	23,811	20,624
6804.22.10	Millstones and grindstones for milling, grinding or pulping, bonded with synthetic resins	9.9c/kg + 3.9 %	Free (A,E,IL,J,MX) 3.9c/kg. + 1.5% (CA)	12,454	27,634
6804.22.40	Abrasive wheels of agglomerated abrasives or of ceramics	3.7%	Free (A,E,IL,J,MX) 1.4% (CA)	11,624	38,273
6804.22.60	Grindstones, etc. of agglomerated abrasives or ceramics	4.9%	Free (A,E,IL,J,MX) 1.9% (CA)	3,598	12,414
6804.23.00	Other millstones, grinding stones, etc. of natural stone	Free		11,340	629
6804.30.00	Hand sharpening or polishing stones	Free		3,917	2,394
6805.10.00	Abrasives on a base of woven textile fabric only	2.5%	Free (A,CA,E,IL,J,MX)	32,627	50,933
6805.20.00	Abrasives on a base of paper or paperboard only	2.5%	Free (A,CA,E,IL,J,MX)	29,449	104,659
6805.30.10	Abrasives coated articles in sheets, strips, disks, belts, etc	2.5%	Free (A,CA,E,IL,J,MX)	46,066	40,528

See footnotes at end of table.

Table 9—Continued
Manufactured abrasives products: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1994; U.S. exports, 1993; and U.S. imports, 1993, continued

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1994 General	Special[1]	U.S. exports, 1993	U.S. imports, 1993
				1,000 dollars	
6805.30.50	Abrasives articles, other	Free		5,118	22,053
7205.10.00	Granules, iron or steel	1%	Free (A,CA,E,IL,J,MX)	16,327	14,156
7205.21.00	Alloy steel powders	4%	Free (A,E,IL,J,MX) 1.6% (CA)	6,521	14,024
7205.29.00	Powders, iron or nonalloy steel	Free		24,478	57,177

[1] Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A); North American Free—Trade Agreement, goods of Canada (CA) and Mexico (MX); Caribbean Basin Economic Recovery Act (E); United States—Israel Free Trade Area (IL); and Andean Trade Preference Act (J).

Source: U.S. exports and imports compiled from official statistics of the U.S. Department of Commerce.

Canada from the United States are due to be phased out by January 1, 1998. Exports of manufactured abrasives from the United States entering Mexico ranged from duty-free to 15 percent ad valorem in 1994. Under terms of NAFTA, all remaining duties on goods entering Mexico from the United States are due to be phased out by January 1, 2003. Foreign tariffs are not considered by U.S. manufacturers to be a significant factor in limiting U.S. exports of manufactured abrasives. Because tariff duties on abrasives entering member countries of GATT from the United States are generally low, the effect of duty reductions agreed to in the Uruguay Round of trade negotiations on existing duties will likely be negligible. Most current U.S. exports are to member countries of the GATT. The Commission is unaware of any nontariff barriers that affect U.S. exports of manufactured abrasives.

U.S. MARKET

Despite a decline in demand for abrasive products by certain end-user markets during 1989-93, the general trend in this market was slightly positive due to strong demand for, and production of, garnet, synthetic diamond, and advanced abrasives and superabrasives. Advanced abrasives and superabrasives are expected to continue to experience double-digit growth during the 1990s as the abrasives industry concentrates on supplying more advanced, higher value-added products to meet the specialized needs of high-technology end-users. Demand for and production of more traditional natural and manufactured abrasives are expected to grow only modestly as end-users continue to pursue efficiencies in their operations by reducing the need for many of these products.

Natural Abrasives

Consumption

Reflecting increased consumption of garnet and synthetic diamond, U.S. apparent consumption of natural abrasives increased during 1989-93 from an estimated $128 million to an estimated $199 million (table 10). This increase occurred despite declines in demand for most other types of natural abrasives. Due principally to the increased substitution of domestically produced synthetic diamond for imported natural diamond, U.S. imports as a percentage of consumption declined from 70 percent in 1989 to 48 percent in 1993.

Production

U.S. production of natural abrasives increased during 1989-93, largely reflecting increased production and use of synthetic diamond in industrial applications during this period. U.S. production of natural abrasives increased by 41 percent, from an estimated $192 million in 1989 to an estimated $271 million in 1993. Synthetic industrial diamond is the largest product segment in this market, accounting for nearly 83 percent of total production in 1993. Production of garnet increased by nearly 27 percent during 1989-93, reflecting increased use of this material in blasting applications. Although production of many natural abrasive products declined during 1989-93 as end-users have continued to substitute manufactured abrasives for many natural abrasives, the industry has been producing a greater proportion of higher value, longer lasting abrasives.

Imports

The major trend occurring in the natural abrasives market during 1989-93 was the substitution of synthetic diamond for natural diamond in abrasives applications as imports of natural diamond declined by nearly 50 percent during this period. Reflecting weak U.S. demand for these traditional abrasive products, U.S. imports of natural abrasives fluctuated during 1989-93, declining from a peak of $108 million in 1990 to $90 million in 1992 (table 11). Imports rose to $96 million in 1993. Natural and synthetic unworked industrial diamond accounted for 70 percent of total product imports in 1993. Ireland supplies large quantities of synthetic industrial diamond powder and dust through General Electric Co.'s division in that country, accounting for 48 percent of total natural abrasive imports in 1993. The United Kingdom accounted for nearly 10 percent of total U.S. imports in 1993; most of the world's rough diamond is sold through orders placed in London.

Imports of natural abrasives entering the U.S. duty-free accounted for 85 percent of total imports in 1993. Imports under the United States-Canada Free-Trade Agreement, the Generalized System of Preferences (GSP), and the Caribbean Basin Economic Recovery Act each accounted for less than 1 percent of total import value in 1993. There were no imports of natural abrasives under the United States-Israel Free-Trade Agreement in 1993.

Manufactured Abrasives

Consumption

Despite slow growth in many traditional end-use markets for manufactured abrasives as industrial end-users continue the use of near-net-shape processes to reduce finishing operations, U.S. manufactured abrasives consumption advanced by a modest 8 percent during 1989-93, from an estimated $2.3 billion to an estimated $2.6 billion, due to strong markets for coated abrasives and advanced abrasives (table 12). U.S. imports accounted for an estimated 22 percent of total

Table 10
Natural abrasives: U.S. production, exports of domestic merchandise, imports for consumption, and apparent consumption, 1989-93

Year	U.S. production[1]	U.S. exports	U.S. imports	Apparent U.S. consumption	Ratio of imports to consumption
	(Million dollars)				*Percent*
1989	192	154	90	128	70
1990	199	137	108	170	64
1991	197	160	86	123	70
1992	233	161	90	162	56
1993	271	168	96	199	48

[1] Estimated by the staff of the U.S. International Trade Commission.

Source: U.S. trade data is compiled from official statistics of the U.S. Department of Commerce.

Table 11
Natural abrasives: U.S. imports for consumption, by principal sources, 1989-93

(1,000 dollars)

Source	1989	1990	1991	1992	1993
Ireland	29,722	41,136	30,057	36,202	46,387
United Kingdom	11,134	15,649	13,085	11,051	9,516
Germany	3,432	3,290	5,906	8,995	10,054
Ghana	3,223	6,813	5,664	4,452	3,339
Japan	3,851	2,796	3,111	2,607	2,923
Switzerland	1,201	1,793	626	2,731	2,360
Zaire	8,516	8,725	6,370	3,226	3,779
Netherlands	1,050	1,786	3,460	2,646	2,186
Turkey	1,539	851	709	1,359	1,915
All other	26,210	24,847	16,911	16,601	13,613
Total	89,878	107,686	85,899	89,870	96,072

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 12
Manufactured abrasives: U.S. production, exports of domestic merchandise, imports for consumption, and apparent consumption, 1989-93

Year	U.S. production[1]	Exports	Imports	Apparent consumption	Ratio of imports to consumption
	(Million dollars)				*Percent*
1989	2,004	154	457	2,387	19
1990	2,156	215	460	2,401	19
1991	2,200	218	439	2,421	18
1992	2,250	258	477	2,469	19
1993	2,300	274	548	2,574	22

[1] Estimated by the staff of the U.S. International Trade Commission.

Source: U.S. trade data is compiled from official statistics of the U.S. Department of Commerce.

manufactured abrasives consumption in 1993, up from an estimated 19 percent in 1989. Industry analysts anticipate modest future growth in demand for manufactured abrasives, although advanced abrasives and superabrasives should continue to gain a greater share of the entire market.

Production

Despite weak demand by large industrial users, U.S. production of manufactured abrasives showed modest increases during 1989-93. U.S. production of manufactured abrasives increased from an estimated $2.0 billion in 1989 to an estimated $2.3 billion in 1993. U.S. production of advanced abrasives and superabrasives for specialized applications increased by double-digit rates during this period, partly compensating for the weaker performance displayed by producers of more traditional, commodity-type manufactured abrasives. Although advanced abrasives and superabrasives currently account for less than 20 percent of total industry production, they tend to be of higher value than commodity-type abrasives, and they can be expected to account for an increasingly larger share of total future abrasives production.

Imports

Despite slow growth in domestic U.S. demand for many abrasive products, the value of U.S. imports of manufactured abrasives increased 20 percent, from $457 million in 1989 to $548 million in 1993, due largely to increased imports of coated abrasives and increased imports of less expensive abrasives from China (table 13). Canada and Germany were the principal suppliers of imports during 1989-93, accounting for 37 percent and 12 percent, respectively, of total imports in 1983. Imports from China grew from 2 percent to 5 percent of total imports during 1989-93 and consisted principally of silicon carbide. Imports of abrasive paper and cloth, coated with natural or artificial abrasive materials, were the leading import category during 1989-93, accounting for 40 percent of manufactured abrasives products entering the United States in 1993.

Imports of manufactured abrasives products entering the United States duty-free accounted for 33 percent of total imports in 1993. Imports under the United States-Canada Free-Trade Agreement and the GSP accounted for 16 and 6 percent, respectively, of total import value in 1993. Imports under the United States-Israel Free-Trade Agreement and the Caribbean Basin Economic Recovery Act each accounted for less than 1 percent of total imports in 1993.

FOREIGN MARKETS

The United States is the leading worldwide producer of total abrasive products and the largest producer of such important natural abrasives as garnet and synthetic diamond, as well as manufactured abrasives. Principal markets for U.S. exports of abrasive products are the advanced industrial nations of Japan, Canada, and Western Europe, which have highly developed automotive, machine tool, and construction industries. Because Japan and Western Europe lack indigenous supplies of most natural abrasives, the United States has become an important supplier of such products as garnet and synthetic diamond to these nations. As is the case with goods sold to the U.S. market, a growing concentration of U.S. exports of abrasives is expected to be composed of advanced abrasive and superabrasive products to meet the needs of specialized high-technology industrial users in these nations.

Natural Abrasives

Foreign Market Profile

Traditional foreign markets for U.S. exports of natural abrasives have included the industrial nations of Japan and Western European nations, whose construction and construction-related industries are significant users of garnet and synthetic diamond. Export markets are expected to change somewhat over time to satisfy the needs of emerging heavy industries in the newly industrialized nations in Asia and Latin America. Because U.S. producers are in the process of significantly expanding their capacity to produce garnet and synthetic diamond in an effort to meet growing worldwide demand, these products are expected to continue as the principal U.S. natural abrasive products exported. The United States is well positioned in the global garnet market because of the high quality and low cost of U.S. garnet reserves and the limited number of foreign producers. The United States also has advantages in exporting synthetic diamond to foreign markets because of its leadership in the production of advanced polycrystalline diamond.

U.S. Exports

As a result of strong foreign markets for synthetic diamond and garnet, U.S. exports of natural abrasives increased from $154 million in 1989 to $168 million in 1993 (table 14). Synthetic diamond dust and powder accounted for 79 percent of total U.S. exports of natural abrasives in 1993. U.S. exports accounted for 62 percent of total production in 1993 compared to 69 percent of total production in 1992. In addition to direct exports, large U.S. firms such as General Electric have also served foreign markets through facilities located in foreign markets.

Table 13
Manufactured abrasives: U.S. imports for consumption, by principal sources, 1989-93

(1,000 dollars)

Source	1989	1990	1991	1992	1993
Canada	166,469	171,502	158,531	177,488	203,694
Germany	48,551	52,441	52,865	57,174	68,018
Japan	40,280	52,920	55,477	58,937	57,019
Italy	24,232	26,807	23,912	25,978	25,229
China	7,379	5,888	10,463	14,573	28,783
Brazil	31,570	17,553	10,195	10,798	12,441
Austria	16,775	17,405	14,913	14,693	14,902
Mexico	14,059	13,450	14,270	13,269	16,243
United Kingdom	11,232	15,258	20,038	17,076	23,213
All other	96,220	86,371	78,604	86,532	98,246
Total	456,767	459,595	439,268	476,518	547,788

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 14
Natural abrasives: U.S. exports of domestic merchandise, by principal markets, 1989-93

(1,000 dollars)

Market	1989	1990	1991	1992	1993
Japan	34,068	26,344	29,094	29,581	35,285
Germany	24,883	23,296	29,417	22,059	24,320
Belgium	19,657	11,201	13,079	19,660	6,016
Ireland	8,580	7,834	5,468	5,313	19,864
S. Korea	5,090	19,893	25,129	22,242	21,262
Canada	8,531	7,222	6,367	6,548	8,671
Italy	10,144	9,222	9,908	9,200	6,436
Brazil	5,926	2,497	3,668	4,534	4,261
Switzerland	3,306	1,502	1,960	4,465	4,159
All other	34,399	28,487	35,428	37,812	37,800
Total	154,184	137,498	159,518	161,414	168,074

Source: Compiled from official statistics of the U.S. Department of Commerce.

Japan is a leading destination for U.S. exports of synthetic diamond dust and powder for use in cutting saws and grinding wheels. Japan was the largest market for U.S. exports of natural abrasives in 1993, receiving 21 percent of total U.S. exports. The value of total exports to Japan rose from $26 million in 1990 to $35 million in 1993. Germany, South Korea, and Ireland were also leading destinations for U.S. exports in 1993, receiving 14, 13, and 12 percent, respectively, of total U.S. exports. Because synthetic diamond accounts for a major proportion of U.S. natural abrasives exports, these industrial nations are expected to continue as principal destinations for U.S. exports of natural abrasives. South Korea has become an important emerging market for U.S. exports of synthetic diamond, increasing its share from 3 percent of total U.S. exports in 1989 to 13 percent in 1993.

Under the NAFTA, the elimination of Mexican duties on natural abrasive products should increase U.S. exports to Mexico. Mexican duty rates on imported natural abrasives during 1989-93 have been much higher than duties imposed by the United States on Mexican goods. Exports to Mexico represented only 1 percent of total U.S. exports in 1993.

Manufactured Abrasives

Foreign Market Profile

Traditional foreign markets for U.S. exports of manufactured abrasives include the advanced industrial nations of Canada, Western Europe, and Japan, whose automobile, machine tool, and construction industries are significant users of manufactured abrasive products. Despite the emphasis on these traditional

geographical markets, many industry analysts have expressed the view that U.S. exporters and other world manufacturers of abrasives increasingly concentrate on boosting sales to rapidly industrializing Asian and Latin American markets. In addition, U.S. manufacturers are seeking to meet the needs of end-users worldwide for longer lasting advanced abrasives and superabrasives to meet increasingly specialized applications. Export sales of superabrasives and advanced sol-gel products are thus far limited, but are expected to account for a larger proportion of future export sales.[54]

U.S. Exports

Due largely to increased exports of coated abrasives to Canada, Germany, and Japan, the overall value of U.S. exports of manufactured abrasives increased by 78 percent from $154 million in 1989 to $274 million in 1993 (table 15). Coated abrasive paper and cloth accounted for 41 percent of total exports in 1993, with millstones and grinding and polishing wheels and stones accounting for 21 percent of total exports. U.S. exports accounted for an estimated 12 percent of total U.S. production in 1993, compared with an estimated 7 percent in 1989, as U.S. exporters took advantage of growth in certain foreign markets to increase exports.

Canada is the largest market for U.S. exports of manufactured abrasives, receiving 36 percent of total exports in 1993. The value of U.S. exports to Canada increased from $39 million in 1989 to $100 million in 1993. U.S. firms also supply Canada directly with significant amounts of abrasives from plants in Canada. Japan was the second-largest market for U.S. exports of manufactured abrasives, receiving 11 percent of U.S. exports in 1993. The value of total exports to Japan rose from $21 million in 1989 to $29 million in 1993. Because manufactured abrasives are principally consumed by major industrial end-users, the major developed nations should continue as the principal market destinations for these products.

[54] Giese, Nov. 1994.

U.S. TRADE BALANCE

Natural Abrasives

The United States has traditionally maintained a trade surplus in natural abrasives because of its strong competitive position in products such as garnet and synthetic industrial diamond. During 1989-93, the U.S. trade surplus in natural abrasives increased from a low of $29 million in 1990 to $72 million in 1993 due to increased substitution of synthetic diamond for imported natural diamond (table 16). The United States maintained a strong trade surplus with Japan and Germany during this period because of the strong competitive position occupied by the U.S. synthetic diamond industry. The U.S. trade surplus with South Korea has grown during this period from $5 million to $20 million because of the growing importance of exports to newly industrializing nations in Asia. Because of continued substitution of synthetic diamond and industry plans to expand production and exports of garnet, trade surpluses are expected to continue into the near future.

Manufactured Abrasives

The United States has traditionally maintained a trade deficit in manufactured abrasives because of its sizeable trade deficit with Canada. However, it is believed that much trade between Canada and the United States is between parent firms in the United States and subsidiaries in Canada. The trade deficit in manufactured abrasives decreased from $303 million in 1989 to $274 million in 1993, largely reflecting an improvement in the deficit with Canada (table 17). The United States also maintains trade deficits with Japan and Germany.

Table 15
Manufactured abrasives: U.S. exports of domestic merchandise, by principal markets, 1989-93

(1,000 dollars)

Market	1989	1990	1991	1992	1993
Canada	39,030	74,465	73,769	82,521	100,247
Japan	21,351	28,868	36,216	34,728	28,772
Mexico	19,408	22,635	24,330	20,110	23,498
Germany	11,027	18,467	19,001	26,767	25,719
United Kingdom	5,680	8,238	8,108	10,727	8,594
Taiwan	2,314	3,441	4,229	7,541	7,512
Netherlands	7,534	6,730	7,146	7,796	7,280
France	6,281	9,910	9,828	10,342	9,989
Australia	6,064	3,795	3,370	4,023	5,337
All other	35,180	38,627	32,439	53,727	57,239
Total	153,869	215,176	218,436	258,282	274,187

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 16
Natural abrasives: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1989-93[1]

(Million dollars)

Item	1989	1990	1991	1992	1993
U.S. exports of domestic merchandise:					
Ireland	9	8	5	5	20
Japan	34	26	29	30	35
Germany	25	23	29	22	24
S. Korea	5	20	25	22	21
United Kingdom	6	6	10	4	6
Canada	9	7	6	7	9
Hong Kong	1	1	1	8	9
Belgium	20	11	13	20	6
Italy	10	9	10	9	6
Switzerland	3	2	2	4	4
All other	32	24	30	30	28
Total	154	137	160	161	168
EU-12	78	63	73	66	66
OPEC	(2)	(2)	1	1	(2)
ASEAN	1	1	1	3	5
CBERA	(2)	(2)	(2)	(2)	(2)
Central Europe	(2)	1	(2)	(2)	(2)
U.S. imports for consumption:					
Ireland	30	41	30	36	46
Japan	4	3	3	3	3
Germany	3	3	6	9	10
S. Korea	(2)	(2)	(2)	(2)	1
United Kingdom	11	16	13	11	10
Canada	1	1	1	1	1
Hong Kong	(2)	1	1	(2)	(2)
Belgium	3	5	1	1	1
Italy	2	1	1	1	1
Switzerland	2	2	(2)	3	2
All other	33	35	19	25	21
Total	90	108	86	90	96
EU-12	51	73	56	63	72
OPEC	4	2	1	1	1
ASEAN	1	1	(2)	(2)	(2)
CBERA	1	1	(2)	(2)	(2)
Central Europe	1	1	1	1	(2)
U.S. merchandise trade balance:					
Ireland	-21	-33	-25	-31	-26
Japan	30	23	26	27	32
Germany	22	20	24	13	14
S. Korea	5	20	25	22	20
United Kingdom	-5	-12	-4	-8	-4
Canada	8	6	6	6	8
Hong Kong	(2)	(2)	(2)	8	9
Belgium	17	6	12	19	5
Italy	8	8	9	8	6
Switzerland	1	-1	1	2	2
All other	(2)	-11	11	5	7
Total	64	29	74	71	72
EU-12	27	-10	17	3	-6
OPEC	-4	-2	-1	(2)	(2)
ASEAN	(2)	(2)	1	3	5
CBERA	-1	(2)	(2)	(2)	(2)
Central Europe	-1	(2)	-1	-1	(2)

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is included in "Germany" but not "Central Europe".

[2] Less than $500,000.

Note.—Because of rounding, figures may not add to the total shown.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 17
Manufactured abrasives: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1989-93[1]

(Million dollars)

Item	1989	1990	1991	1992	1993
U.S. exports of domestic merchandise:					
Canada	39	74	74	83	100
Japan	21	29	36	35	29
Germany	11	18	19	27	26
Mexico	19	23	24	20	24
United Kingdom	6	8	8	11	9
Italy	3	5	3	4	3
S. Korea	2	3	3	5	6
Finland	(2)	(2)	(2)	(2)	(2)
France	6	10	10	10	10
Taiwan	2	3	4	8	8
All other	45	42	37	55	59
Total	154	215	218	258	274
EU-12	37	52	52	73	66
OPEC	2	3	2	3	2
ASEAN	4	4	3	6	7
CBERA	2	2	1	1	2
Central Europe	1	(2)	(2)	(2)	(2)
U.S. imports for consumption:					
Canada	166	172	159	177	204
Japan	40	53	55	59	57
Germany	49	52	53	57	68
Mexico	14	13	14	13	16
United Kingdom	11	15	20	17	23
Italy	24	27	24	26	25
S. Korea	11	12	12	11	13
Finland	6	9	12	18	16
France	6	5	6	6	8
Taiwan	7	8	9	8	8
All other	123	94	75	85	110
Total	457	460	439	477	548
EU-12	98	109	114	116	134
OPEC	(2)	(2)	4	4	2
ASEAN	1	2	2	2	3
CBERA	7	11	(2)	1	1
Central Europe	1	(2)	1	1	1
U.S. merchandise trade balance:					
Canada	-127	-98	-85	-94	-104
Japan	-19	-24	-19	-24	-28
Germany	-38	-34	-34	-30	-42
Mexico	5	10	10	7	8
United Kingdom	-5	-7	-12	-6	-14
Italy	-21	-22	-21	-22	-22
S. Korea	-9	-9	-9	-6	-7
Finland	-6	-9	-12	-18	-16
France	(2)	-5	-4	-4	-2
Taiwan	5	5	5	(2)	(2)
All other	-78	-52	-38	-30	-51
Total	-303	-245	-221	-219	-274
EU-12	-61	-57	-62	-43	-68
OPEC	2	3	-2	-1	(2)
ASEAN	3	2	1	4	4
CBERA	-5	-9	1	(2)	1
Central Europe	(2)	(2)	-1	-1	-1

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S trade with East Germany is included in "Germany" but not "Central Europe".

[2] Less than $500,000.

Note.—Because of rounding, figures may not add to the totals shown.

Source: Compiled from official statistics of the U.S. Department of Commerce.

APPENDIX A
STATISTICAL TABLES

Table A-1
Total abrasives: U.S. production, exports of domestic merchandise, imports for consumption, and apparent consumption, 1989-93

Year	U.S. production[1]	Exports	Imports	Apparent consumption	Ratio of imports to consumption
		(Million dollars)			*Percent*
1989	2,196	308	547	2,435	22
1990	2,355	353	567	2,569	22
1991	2,397	378	525	2,544	21
1992	2,483	420	566	2,629	22
1993	2,571	442	644	2,773	23

[1] Estimated by the staff of the U.S. International Trade Commission.

Source: U.S. trade data is compiled from official statistics of the U.S. Department of Commerce.

Table A-2
Total abrasives: U.S. exports of domestic merchandise, by principal markets, 1989-93

(1,000 dollars)

Market	1989	1990	1991	1992	1993
Canada	47,561	81,687	80,136	89,069	108,918
Germany	35,910	41,763	48,418	48,826	50,039
Japan	55,419	55,212	65,310	64,309	64,057
Ireland	9,200	8,438	6,110	5,696	20,108
United Kingdom	11,938	13,993	17,637	14,266	14,112
Italy	13,341	14,547	13,345	12,930	9,613
Mexico	22,396	25,604	27,671	22,663	25,207
Belgium	19,657	12,621	14,517	21,450	7,717
S. Korea	7,191	23,169	28,257	27,163	26,919
France	10,873	13,148	13,855	14,051	12,189
All other	74,567	62,492	62,698	99,273	103,382
Total	308,053	352,674	377,954	419,696	442,261

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table A-3
Total abrasives: U.S. imports for consumption, by sources, 1989-93

(1,000 dollars)

Source	1989	1990	1991	1992	1993
Canada	167,024	172,546	159,318	178,368	204,561
Germany	51,983	55,731	58,771	66,169	78,072
Japan	44,131	56,716	58,580	61,544	59,942
Ireland	31,692	43,081	31,743	37,084	47,359
United Kingdom	22,366	30,907	33,123	28,118	32,729
China	7,767	6,710	11,690	15,662	30,722
Italy	25,842	27,865	24,841	26,955	25,853
Mexico	17,099	15,558	16,857	14,210	16,569
Austria	16,882	17,490	14,937	14,708	14,933
S. Korea	11,732	11,702	11,619	11,091	13,931
All other	150,127	128,975	103,688	112,479	119,189
Total	546,645	567,281	525,167	566,388	643,860

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table A-4
Total abrasives: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1989-93[1]

(Million dollars)

Item	1989	1990	1991	1992	1993
U.S. exports of domestic merchandise:					
Canada	48	74	80	89	108
Japan	55	55	65	64	64
Germany	36	42	48	49	50
Mexico	22	26	28	23	25
Ireland	9	8	6	6	20
United Kingdom	12	14	18	14	14
Italy	13	15	13	13	10
S. Korea	7	23	28	27	27
France	11	13	14	14	12
Belgium	20	13	15	21	8
All other	75	70	73	100	104
Total	308	353	378	420	442
EU-12	115	115	125	139	132
OPEC	2	3	3	4	3
ASEAN	5	5	5	9	12
CBERA	2	2	1	1	2
Central Europe	1	1	(2)	(2)	(2)
U.S. imports for consumption:					
Canada	167	173	159	178	205
Japan	44	57	59	62	60
Germany	52	56	59	66	78
Mexico	17	16	17	14	17
Ireland	32	43	32	37	47
United Kingdom	22	31	33	28	33
Italy	29	28	25	27	26
S. Korea	12	12	12	11	14
France	6	5	6	6	8
Belgium	5	8	5	3	4
All other	161	138	118	134	152
Total	547	567	525	566	644
EU-12	182	220	205	219	237
OPEC	4	3	6	5	3
ASEAN	3	3	2	3	3
CBERA	8	11	(2)	1	1
Central Europe	2	1	2	2	1
U.S. merchandise trade balance:					
Canada	-119	-99	-79	-89	-97
Japan	11	-2	6	2	4
Germany	-16	-14	-11	-17	-28
Mexico	5	10	11	9	8
Ireland	-23	-35	-26	-31	-27
United Kingdom	-10	-17	-15	-14	-19
Italy	-16	-13	-12	-14	-16
S. Korea	-5	11	16	16	13
France	5	8	8	8	4
Belgium	15	5	10	18	4
All other	-86	-68	-45	-34	-48
Total	-239	-214	-147	-146	-202
EU-12	-67	-105	-80	-80	-105
OPEC	-2	(2)	-3	-1	(2)
ASEAN	2	2	3	6	9
CBERA	-6	-9	-1	(2)	1
Central Europe	-1	(2)	-2	-2	-1

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is included in "Germany" but not "Central Europe".

[2] Less than $500,000.

Note.—Because of rounding, figures may not add to the totals shown.
Source: Compiled from official statistics of the U.S. Department of Commerce.

APPENDIX B
EXPLANATION OF TARIFF AND TRADE AGREEMENT TERMS

The ***Harmonized Tariff Schedule of the United States*** (HTS) replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989. Chapters 1 through 97 incorporate the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description and have U.S. product subdivisions at the 8-digit level. Chapters 98 and 99 contain special U.S. classifications and temporary rate provisions, respectively.

Duty rates in the ***general*** subcolumn of HTS column 1 are most-favored-nation (MFN) rates, many of which have been eliminated or are being reduced as concessions resulting from the Uruguay Round of Multilateral Trade Negotiations. Column 1-general duty rates apply to all countries except those enumerated in HTS general note 3(b) (Afghanistan, Azerbaijan, Cuba, Kampuchea, Laos, North Korea, and Vietnam), which are subject to the rates set forth in ***column 2***. Albania, Armenia, Belarus, Bosnia, Bulgaria, the People's Republic of China, Croatia, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan are accorded MFN treatment. Specified goods from designated MFN-eligible countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the ***special*** subcolumn of HTS column 1 or in the general notes. If eligibility for special tariff rates is not claimed or established, goods are dutiable at column 1-general rates. The HTS does not enumerate those countries as to which a total or partial embargo has been declared.

The ***Generalized System of Preferences*** (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 for 10 years and extended three times thereafter, applies to merchandise imported on or after January 1, 1976 and before the close of July 30, 1995. Indicated by the symbol "A" or "A*" in the special subcolumn, the GSP provides duty-free entry to eligible articles the product of and imported directly from designated beneficiary developing countries, as set forth in general note 4 to the HTS.

The ***Caribbean Basin Economic Recovery Act*** (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984. Indicated by the symbol "E" or "E*" in the special subcolumn, the CBERA provides duty-free entry to eligible articles, and reduced-duty treatment to certain other articles, which are the product of and imported directly from designated countries, as set forth in general note 7 to the HTS.

Free rates of duty in the special subcolumn followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free Trade Area Implementation Act*** of 1985 (IFTA), as provided in general note 8 to the HTS.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the ***Andean Trade Preference Act*** (ATPA), enacted as title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 11 to the HTS.

Preferential or free rates of duty in the special subcolumn followed by the symbol "CA" are applicable to eligible goods of Canada, and those followed by the symbol "MX" are applicable to eligible goods of Mexico, under the ***North American Free Trade Agreement***, as provided in general note 12 to the HTS, implemented effective January 1, 1994 by Presidential Proclamation 6641 of December 15, 1993.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), goods covered by the ***Automotive Products Trade Act*** (APTA) (general note 5) and the ***Agreement on Trade in Civil Aircraft*** (ATCA) (general note 6), ***articles imported from freely associated states*** (general note 10), ***pharmaceutical products*** (general note 13), and ***intermediate chemicals for dyes*** (general note 14).

The ***General Agreement on Tariffs and Trade 1994*** (GATT 1994), annexed to the Agreement Establishing the World Trade Organization, replaces an earlier agreement (the GATT 1947 [61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786]) as the primary multilateral system of disciplines and

principles governing international trade. Signatories' obligations under both the 1994 and 1947 agreements focus upon most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national (nondiscriminatory) treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, antidumping and countervailing duties, dispute settlement, and other measures. The results of the Uruguay Round of multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX.

Officially known as "The Arrangement Regarding International Trade in Textiles," the ***Multifiber Arrangement*** (MFA) provides a framework for importing and exporting countries to negotiate bilateral agreements limiting textile and apparel shipments, or for importing countries to take unilateral action in the absence or violation of an agreement. These agreements establish quantitative limits on textiles and apparel of cotton, other vegetable fibers, wool, man-made fibers or silk blends in an effort to prevent or limit market disruption in the importing countries—restrictions that would otherwise be a departure from GATT provisions. The United States has bilateral agreements with many supplying countries, including the four largest suppliers: China, Hong Kong, the Republic of Korea, and Taiwan.